Nanotechnology Corrosion Pretreatment for Magnesium Alloys

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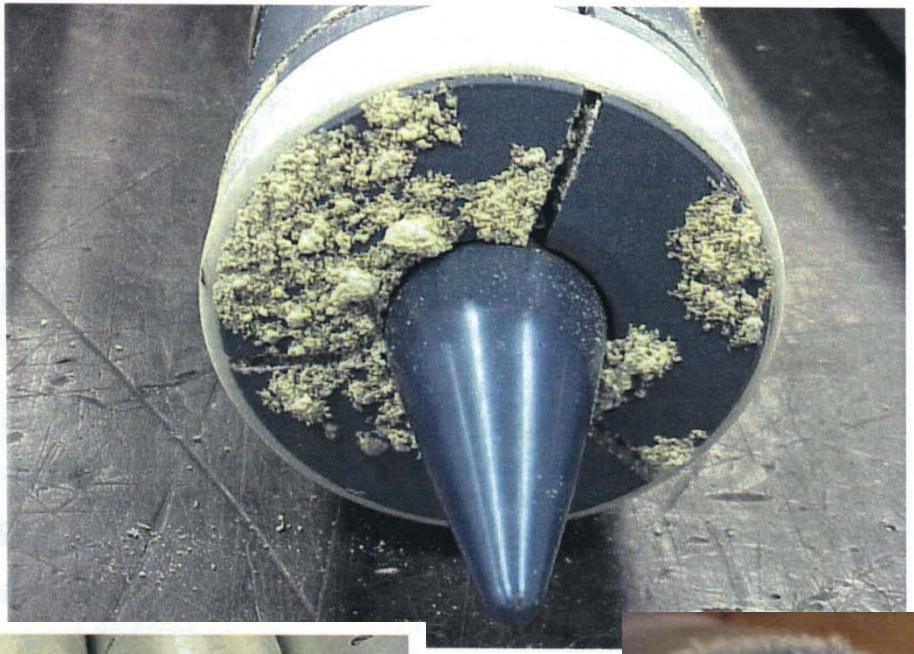
Program Objective:

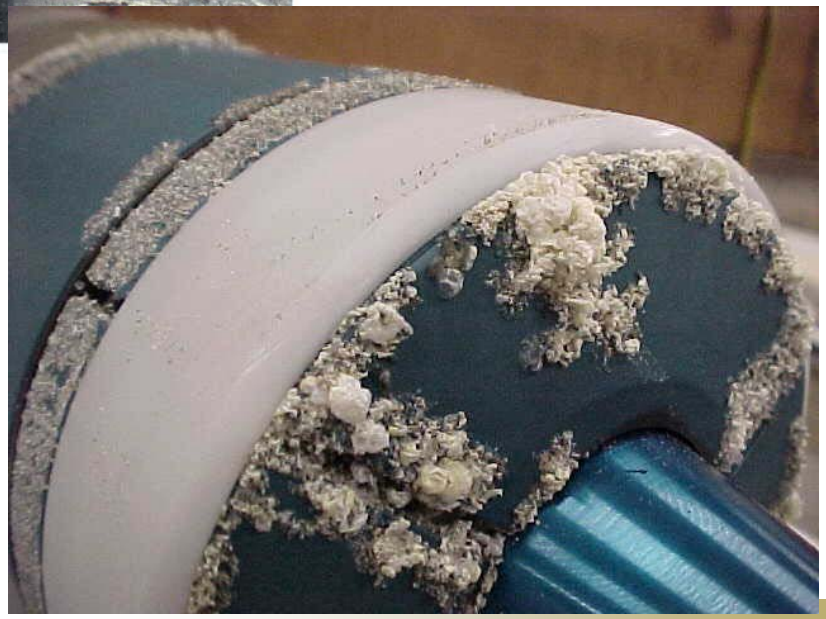
- Enhance corrosion resistance of lightweight magnesium alloys using novel chromate (hexavalent chromium (Cr^{6+})) free self-healing pretreatments

Potential Army Benefits

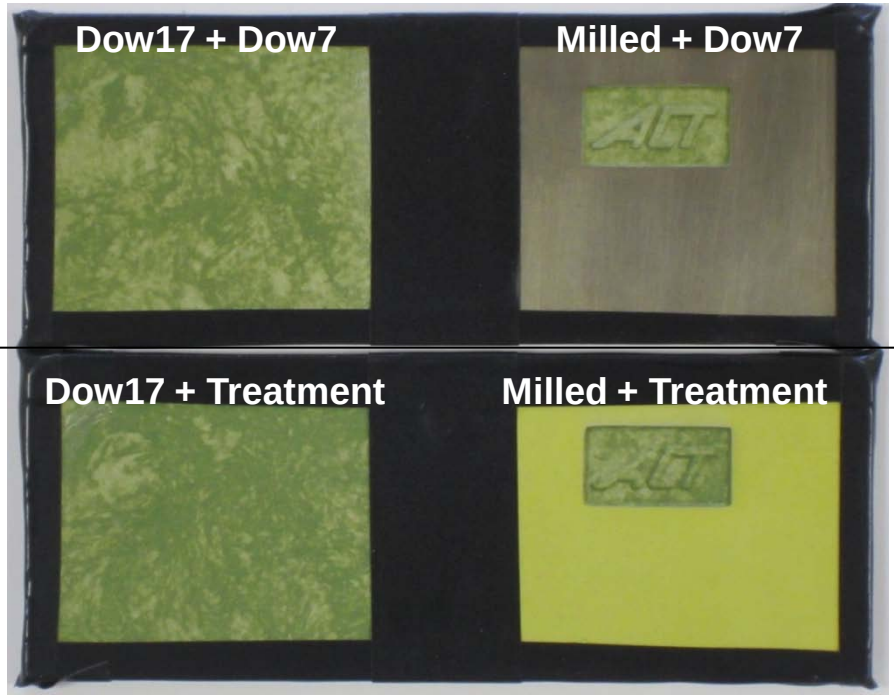
- Reduction in the environmental, health, and safety hazards associated with exposure to Cr^{6+}
- Compliance with Under Secretary of Defense for AT&L's memo on hexavalent chromium reduction
- Enhanced corrosion resistance and "paintability" of lightweight alloys
- Decreased commodity weights through use of magnesium as replacements for aluminum and steel

Nano Pretreatment for Magnesium Alloys





0 hr SST*

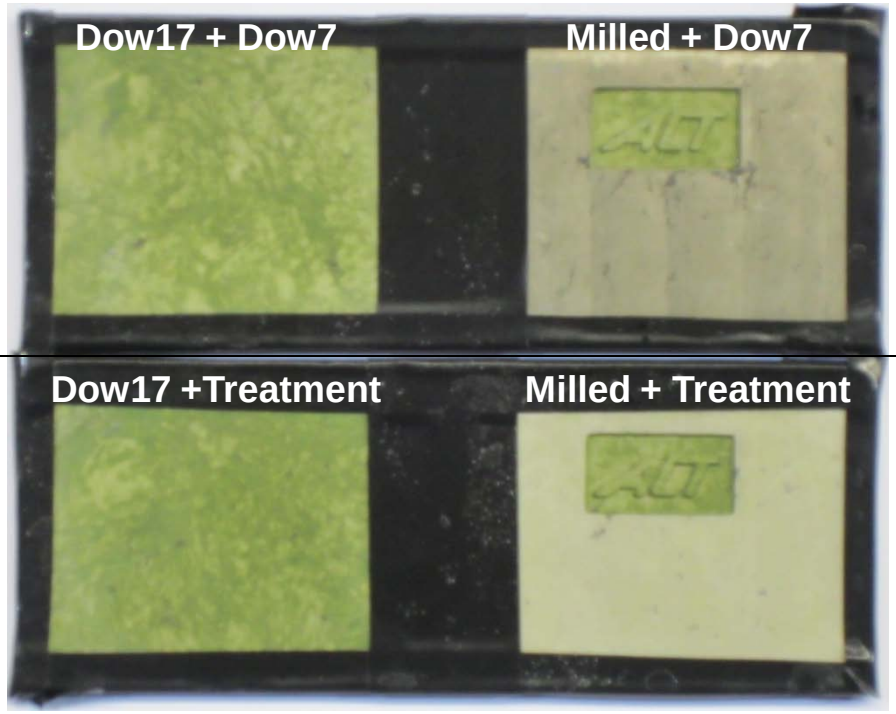


Dow7 (Chromium Conversion Coating) vs. Treatment over Dow17 (Chromium Anodized Coating) and Milled AZ91D

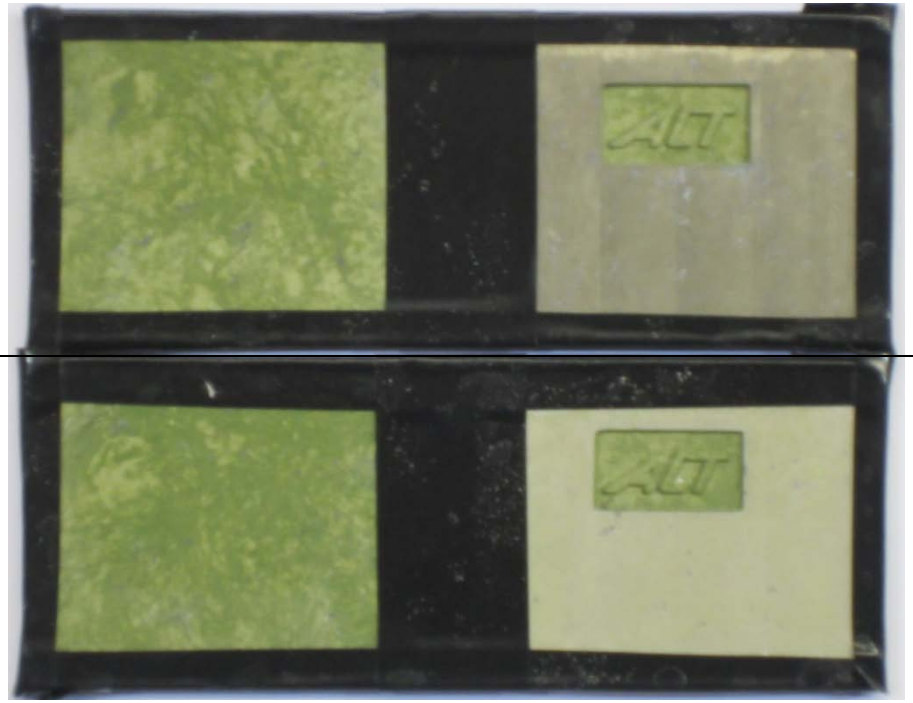
* SST=ASTM B117 Salt Spray Test

24h SST

Wet

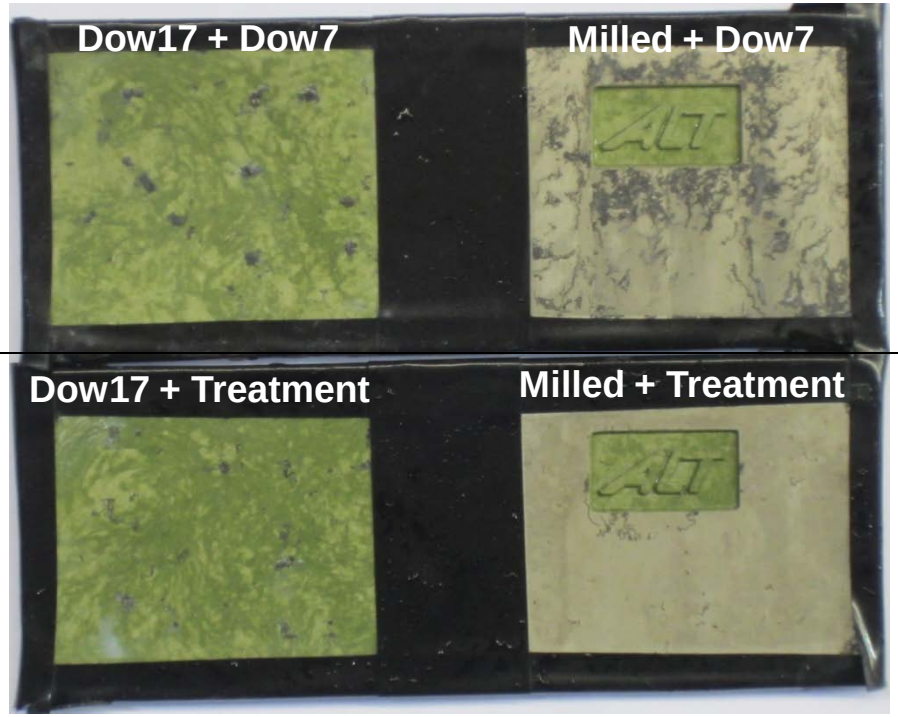


Dry



168 hrs SST

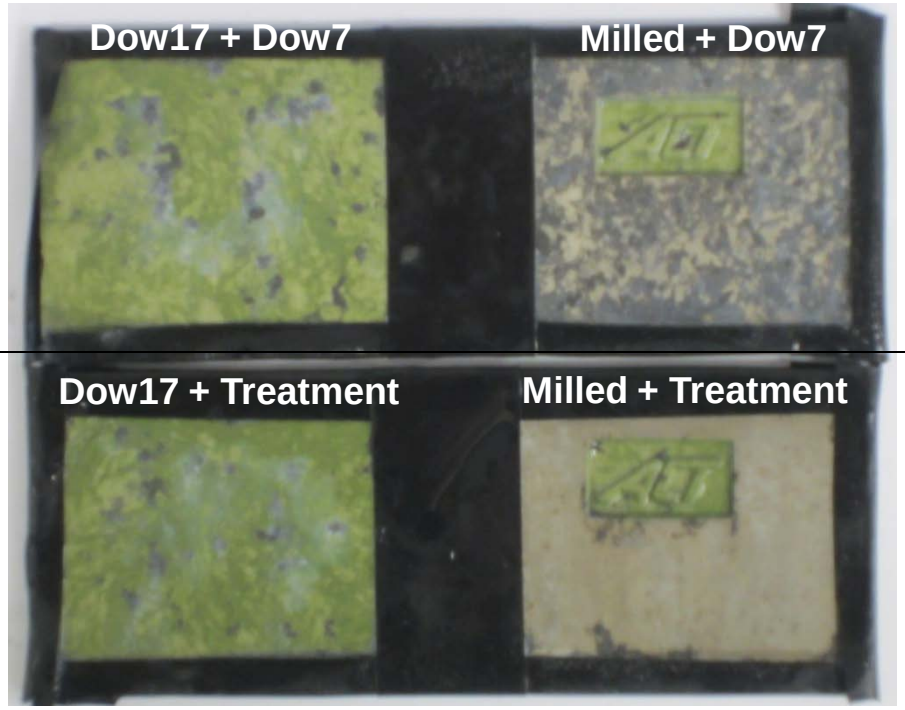
Wet



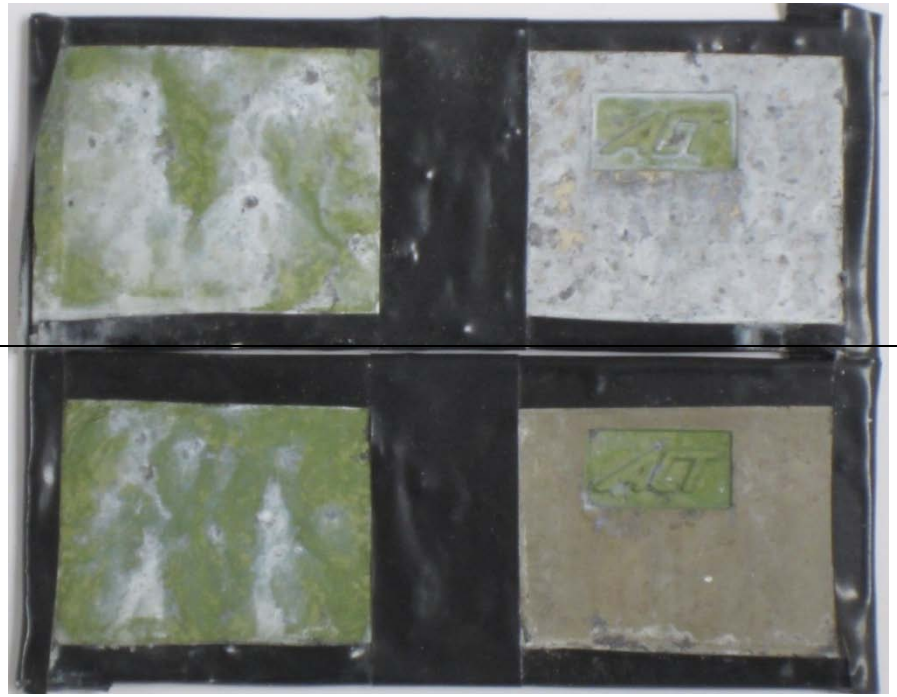
Dry

504 hrs SST

Wet



Dry



Samples for Salt-Spray Test (ASTM B117 SST)

0 hr SST

Dow17 (Chromium based anodized coating)

Dow17 + Treatment (Chromium free conversion coating)

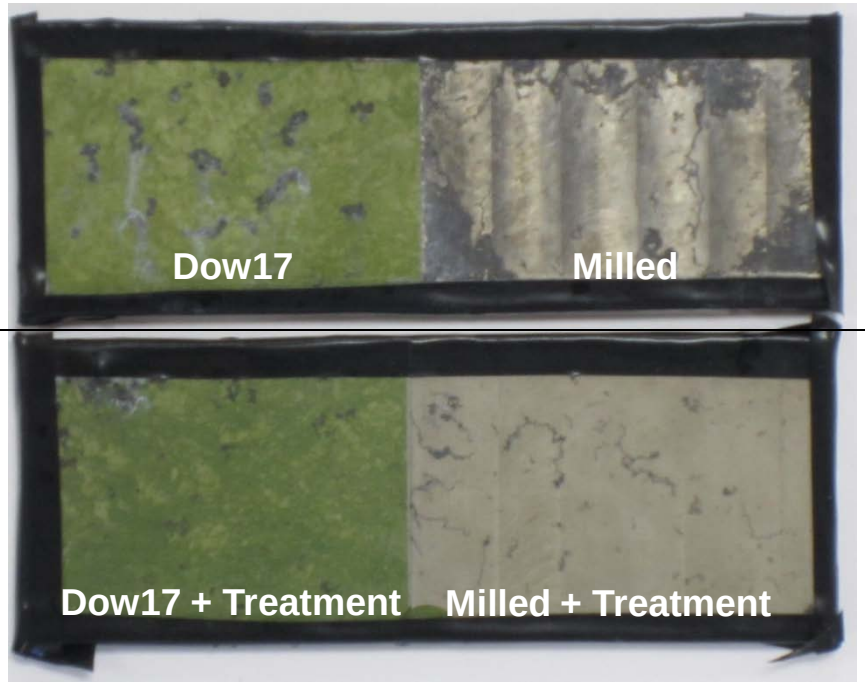
Milled

Milled + Treatment

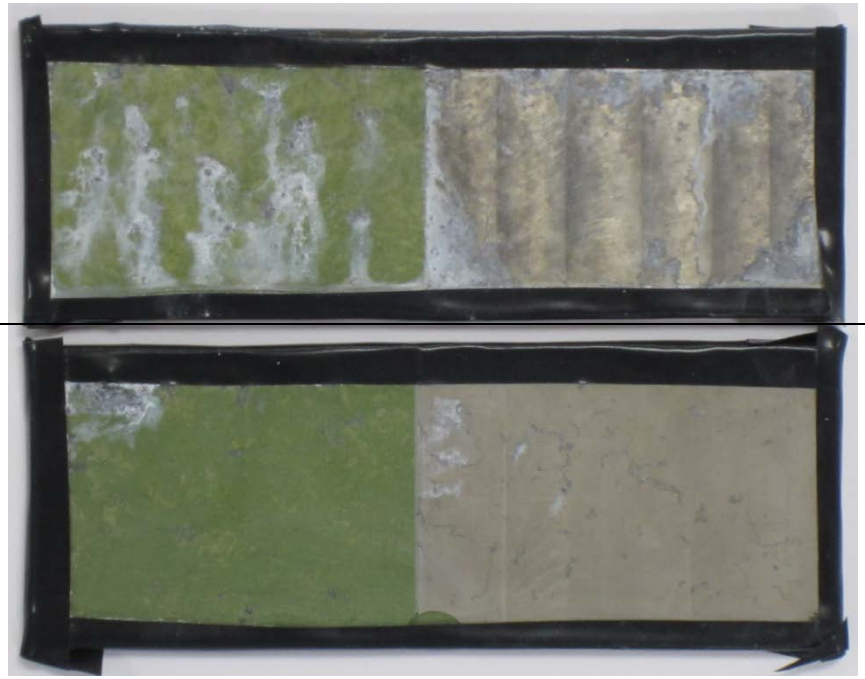
Mg AZ91D

168 hrs SST

Wet



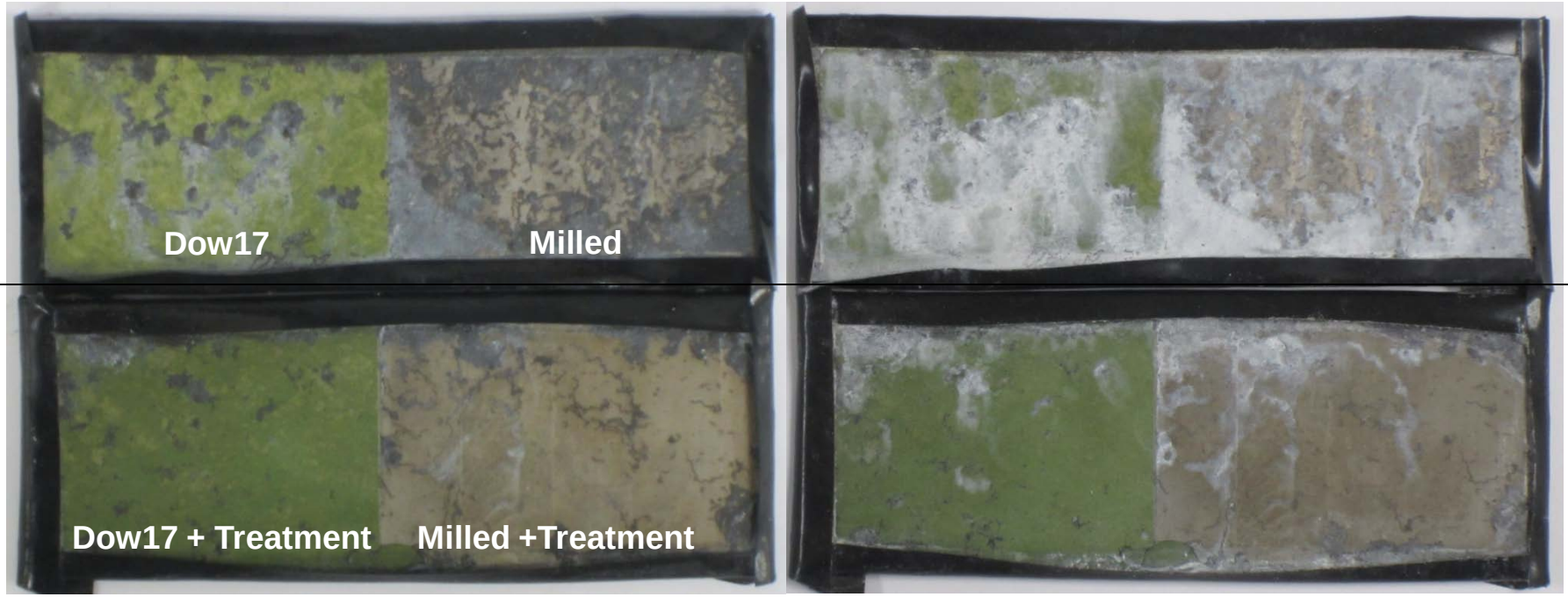
Dry



768 hrs SST

Wet

Dry

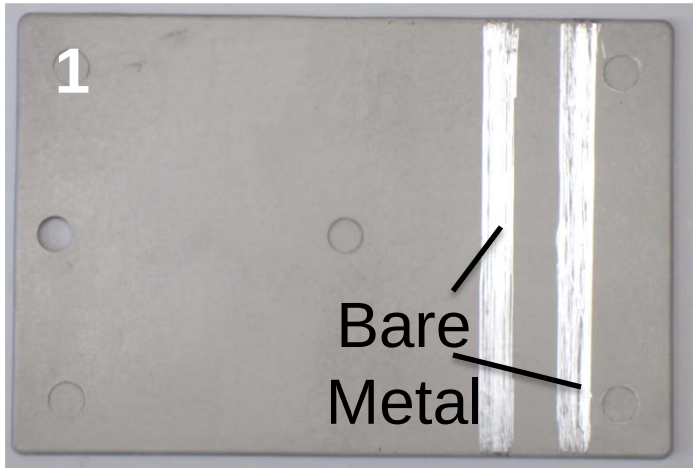


Compare the corrosion observed on Dow17 surface with the Dow17 + Treatment

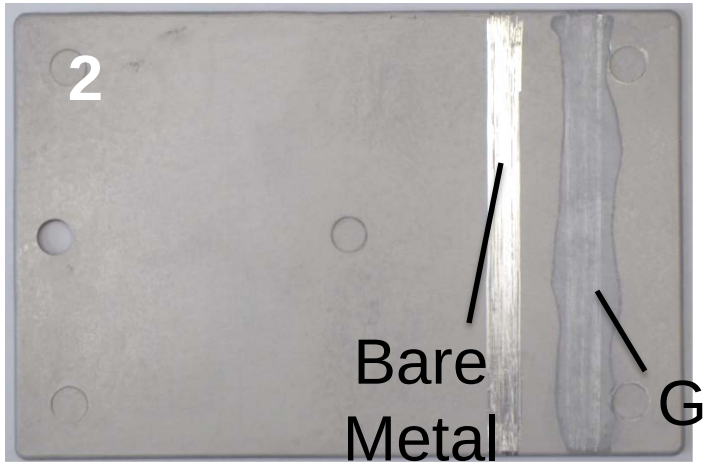
Note the corrosion on Milled surface and the Milled + Treatment as well as Dow17 and Milled + Treatment

Nano Pretreatment for Magnesium Alloys

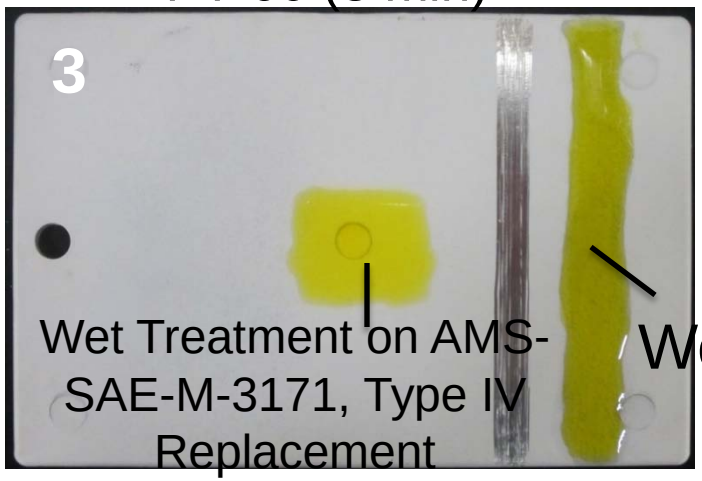
AMS-SAE-M-3171, Type IV Replacement on AZ91D



Glycolic Nitrate Pickle (GNP) (1 min)

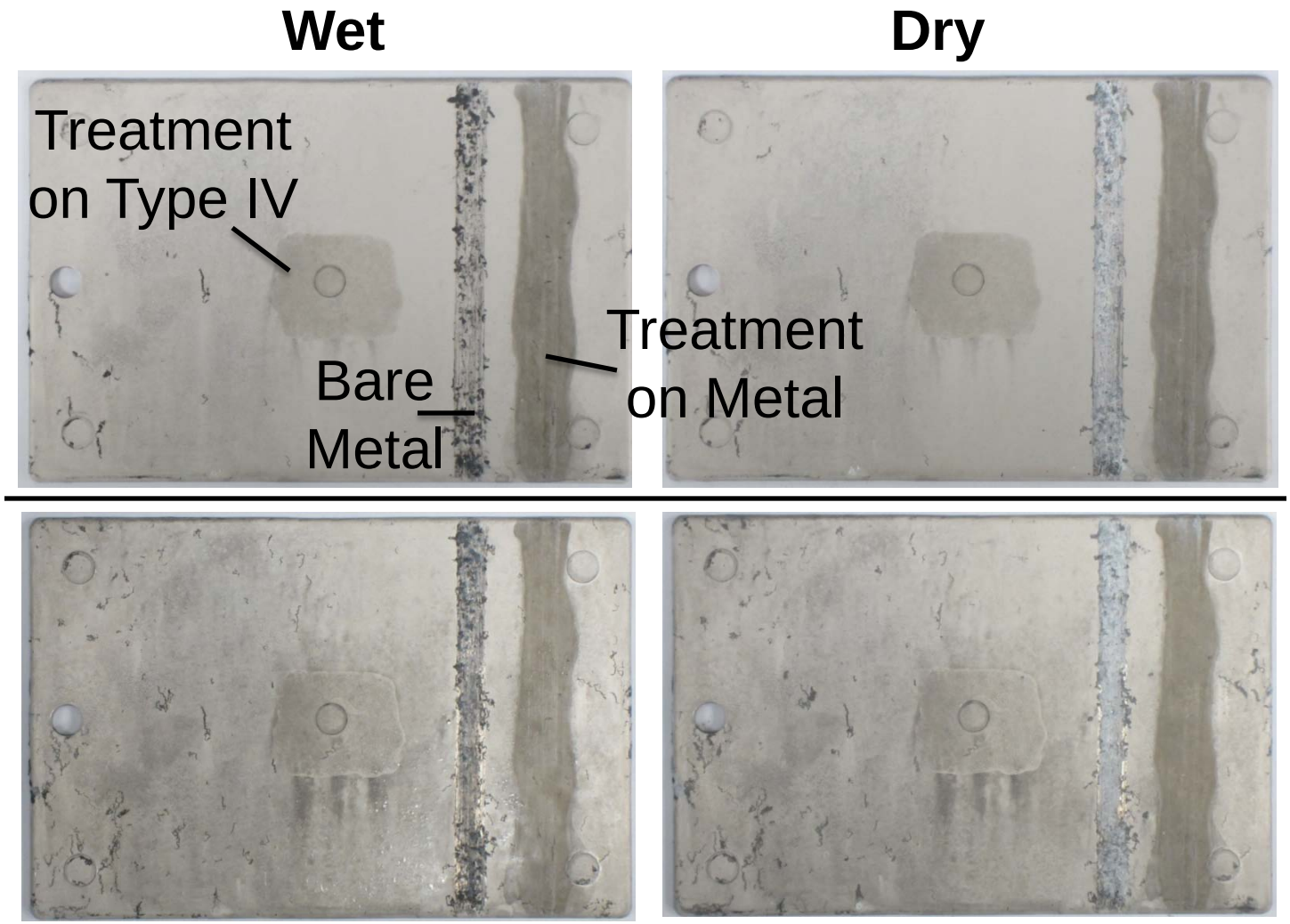


PT-60 (3 min)



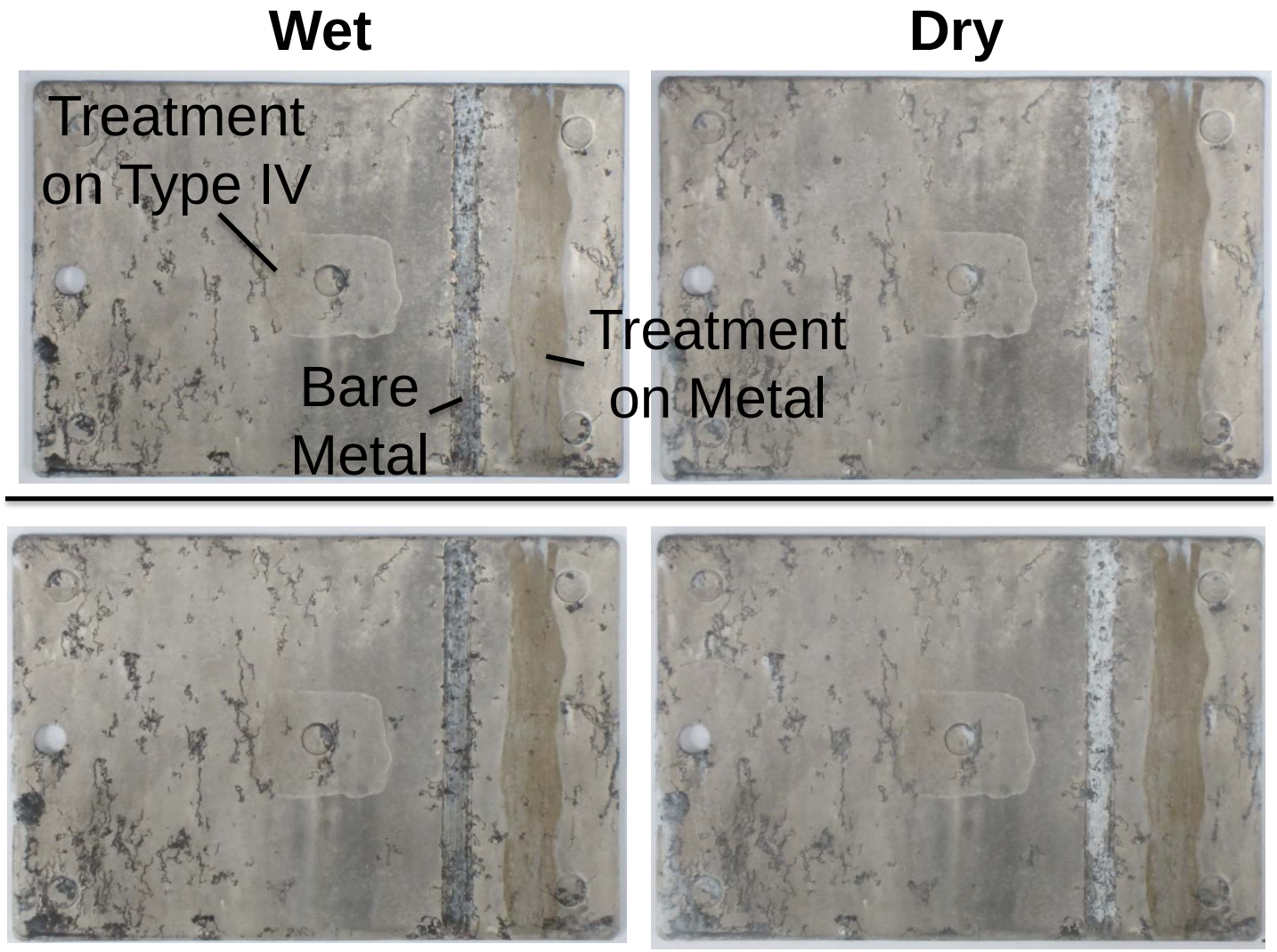
0 hr SST

Nano Pretreatment for Magnesium Alloys



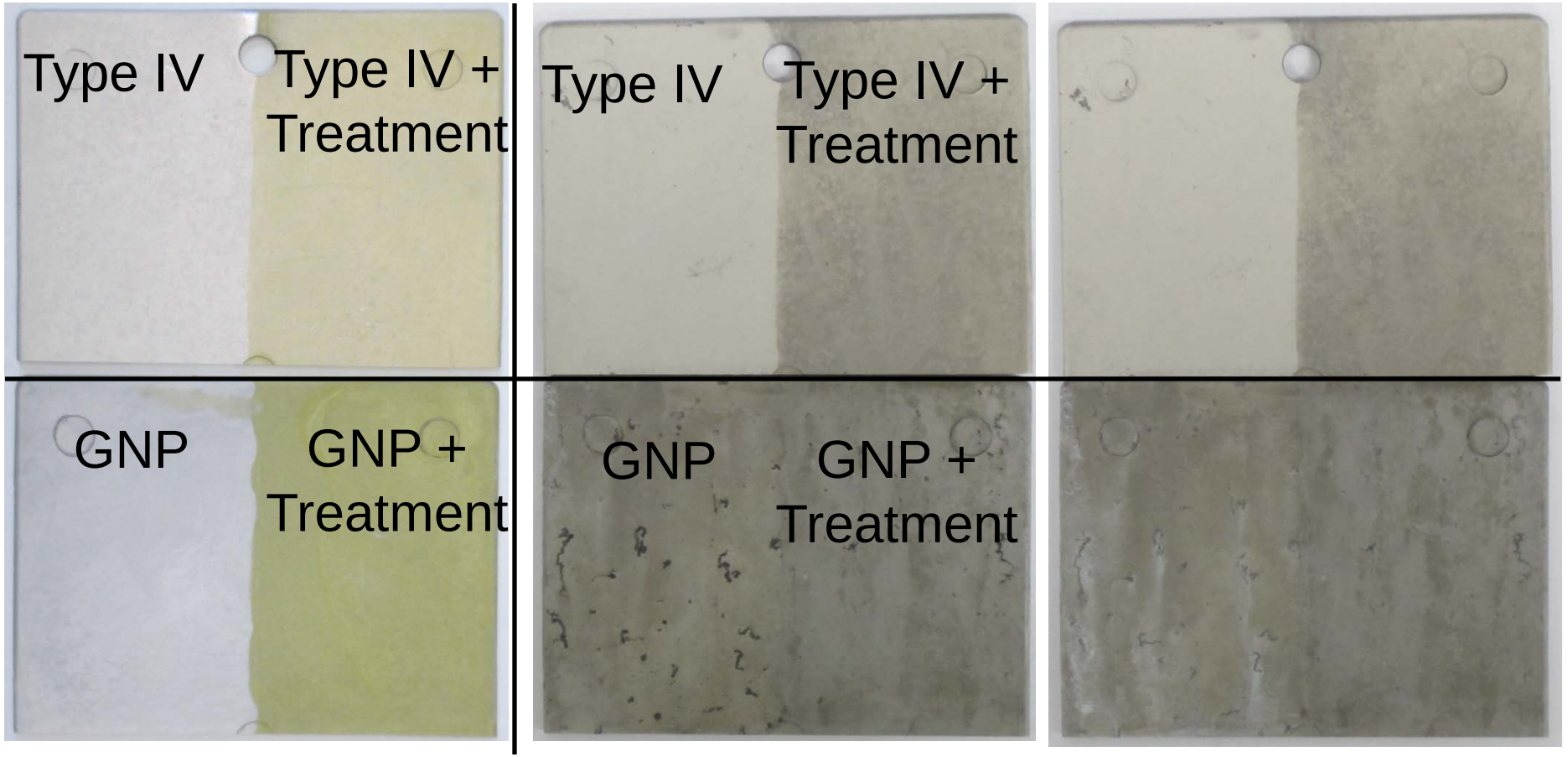
AMS-SAE-M-3171, Type IV Replacement = Type IV

Nano Pretreatment for Magnesium Alloys



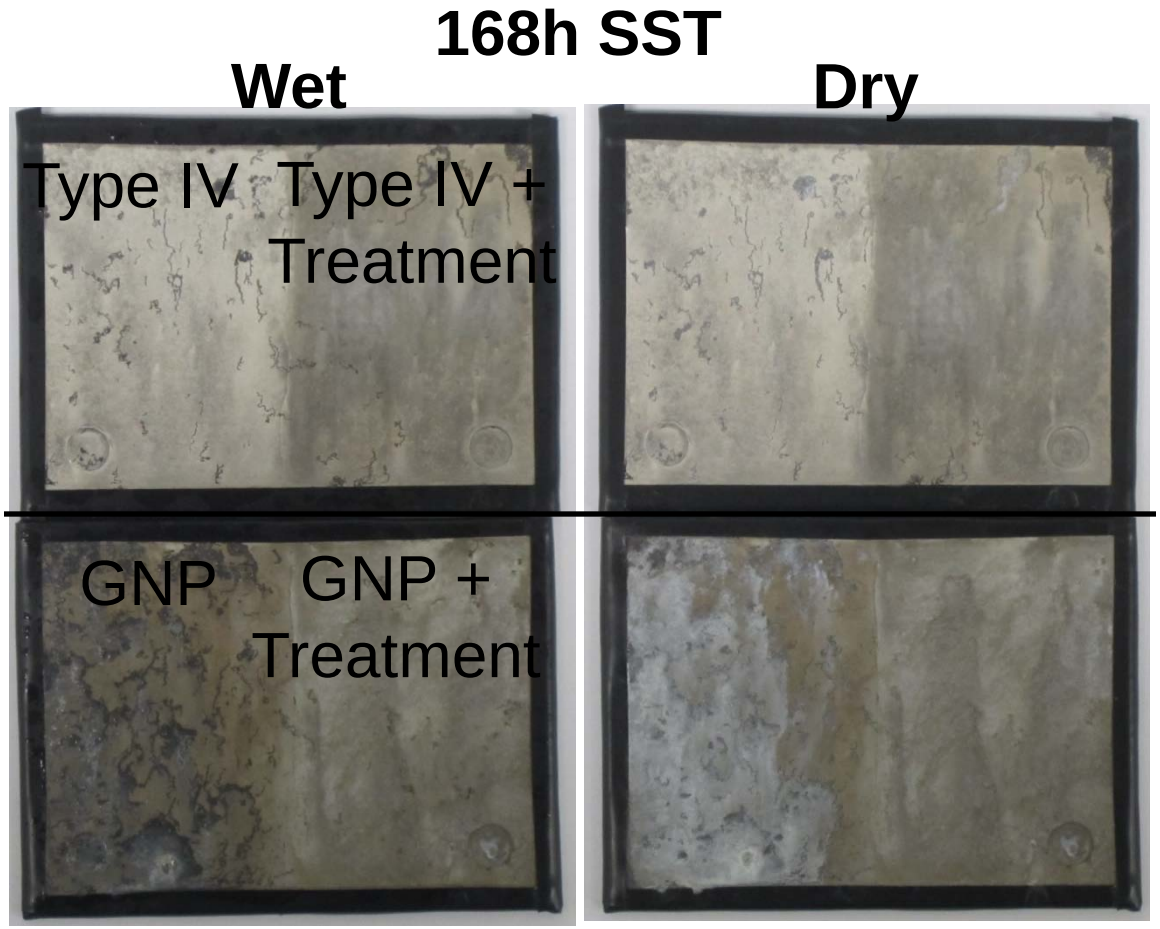
AMS-SAE-M-3171, Type IV Replacement = Type IV

Nano Pretreatment for Magnesium Alloys



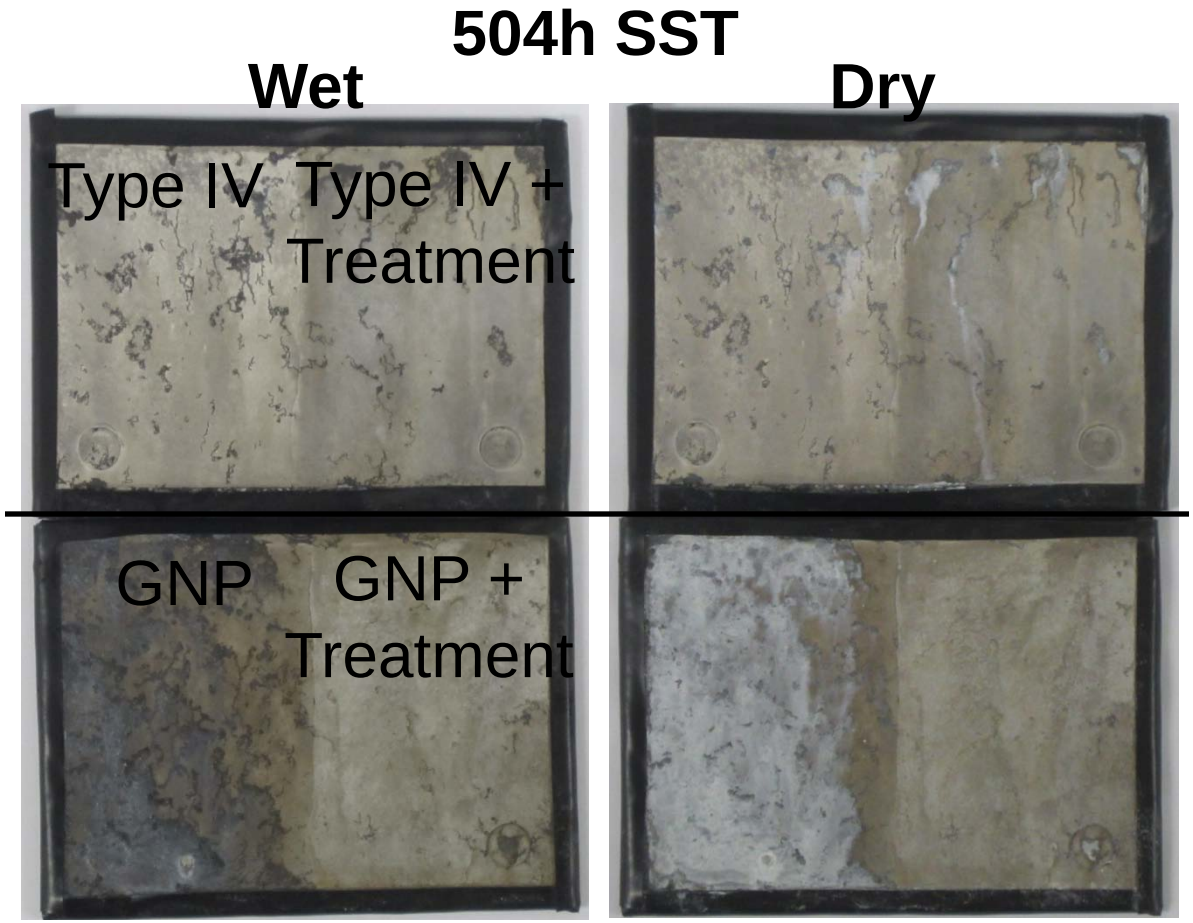
AMS-SAE-M-3171, Type IV Replacement = Type IV

Nano Pretreatment for Magnesium Alloys



AMS-SAE-M-3171, Type IV Replacement = Type IV

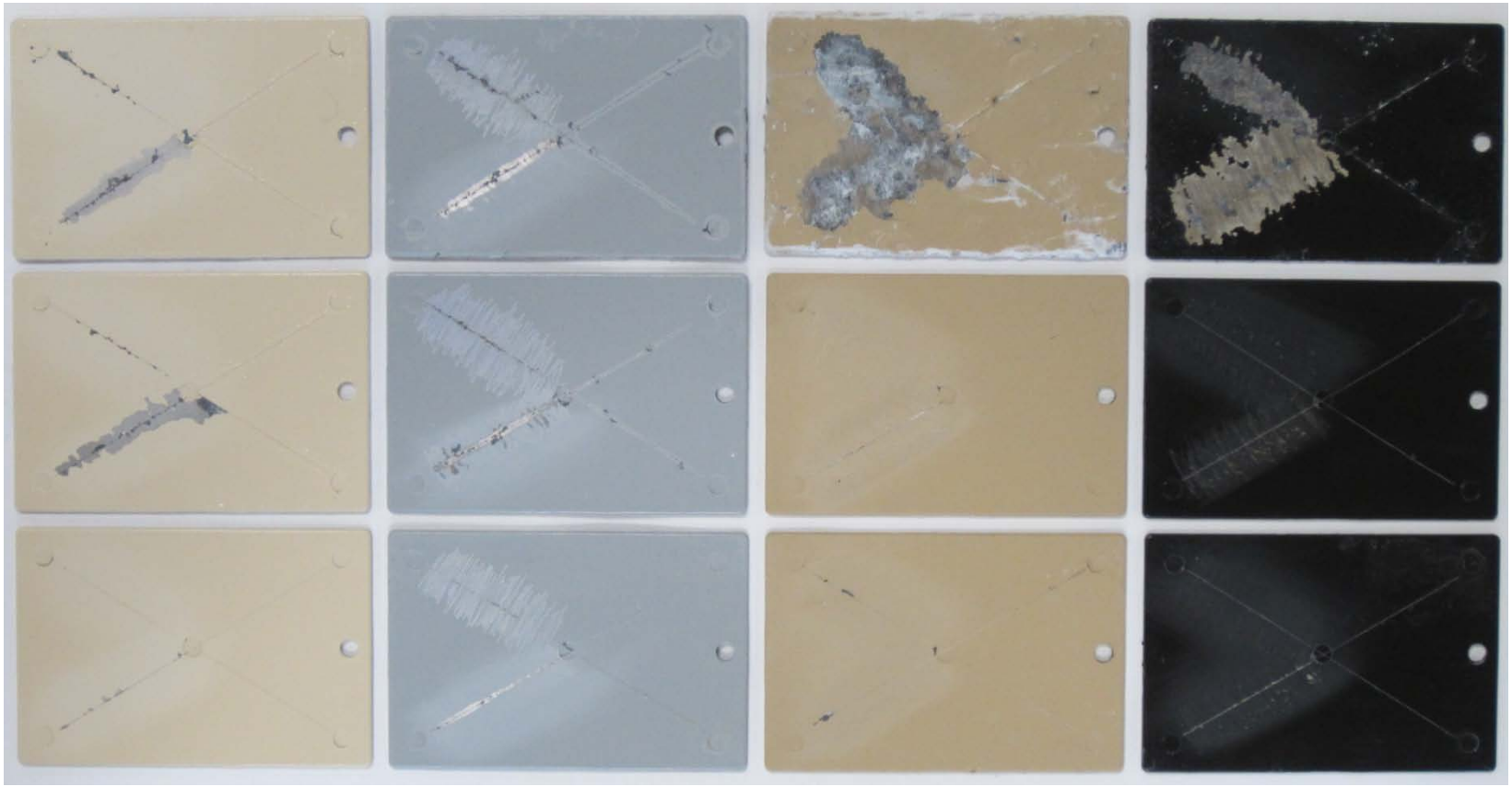
Nano Pretreatment for Magnesium Alloys



AMS-SAE-M-3171, Type IV Replacement = Type IV

Nano Pretreatment for Magnesium Alloys

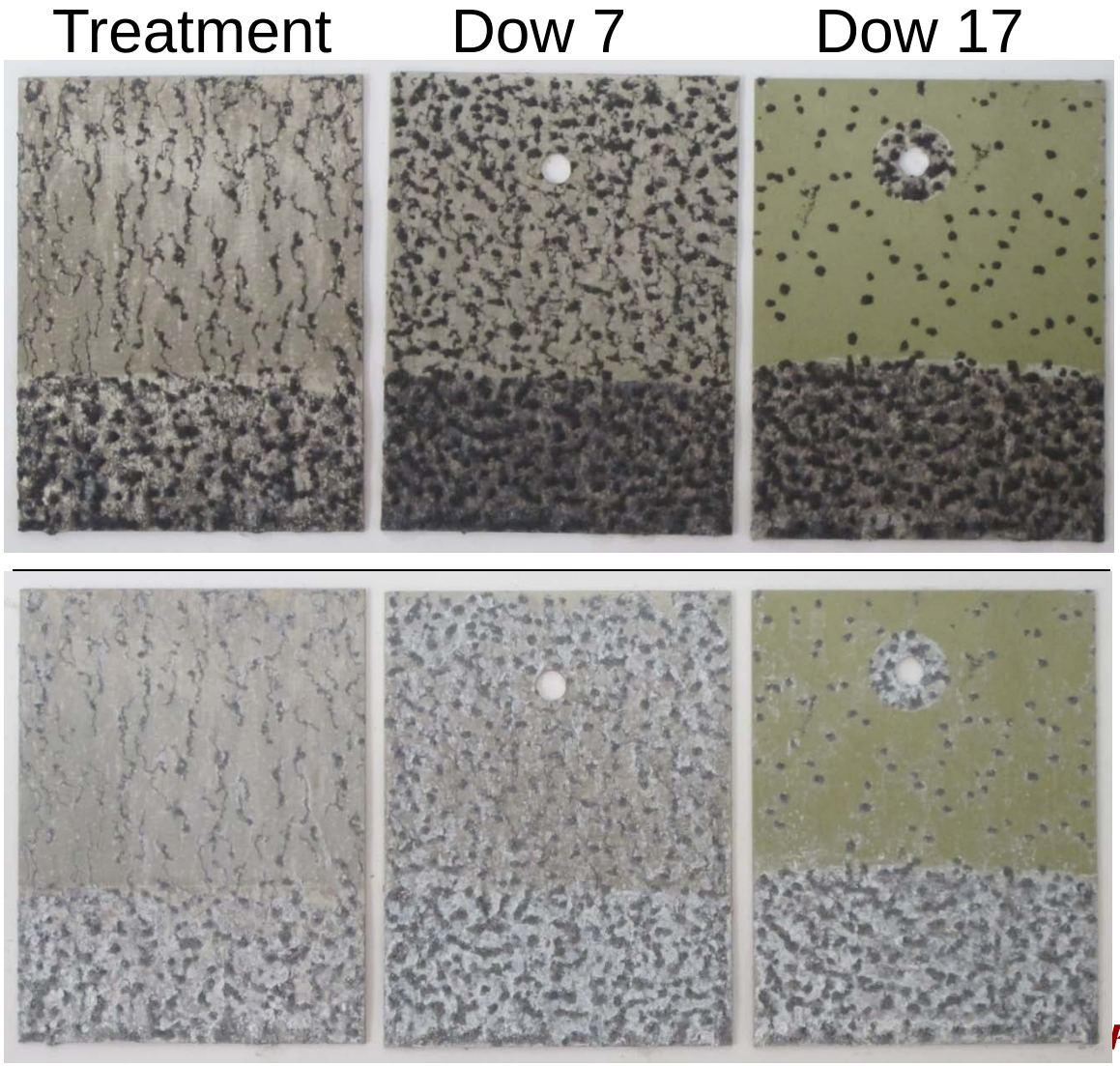
AZ91D Panels



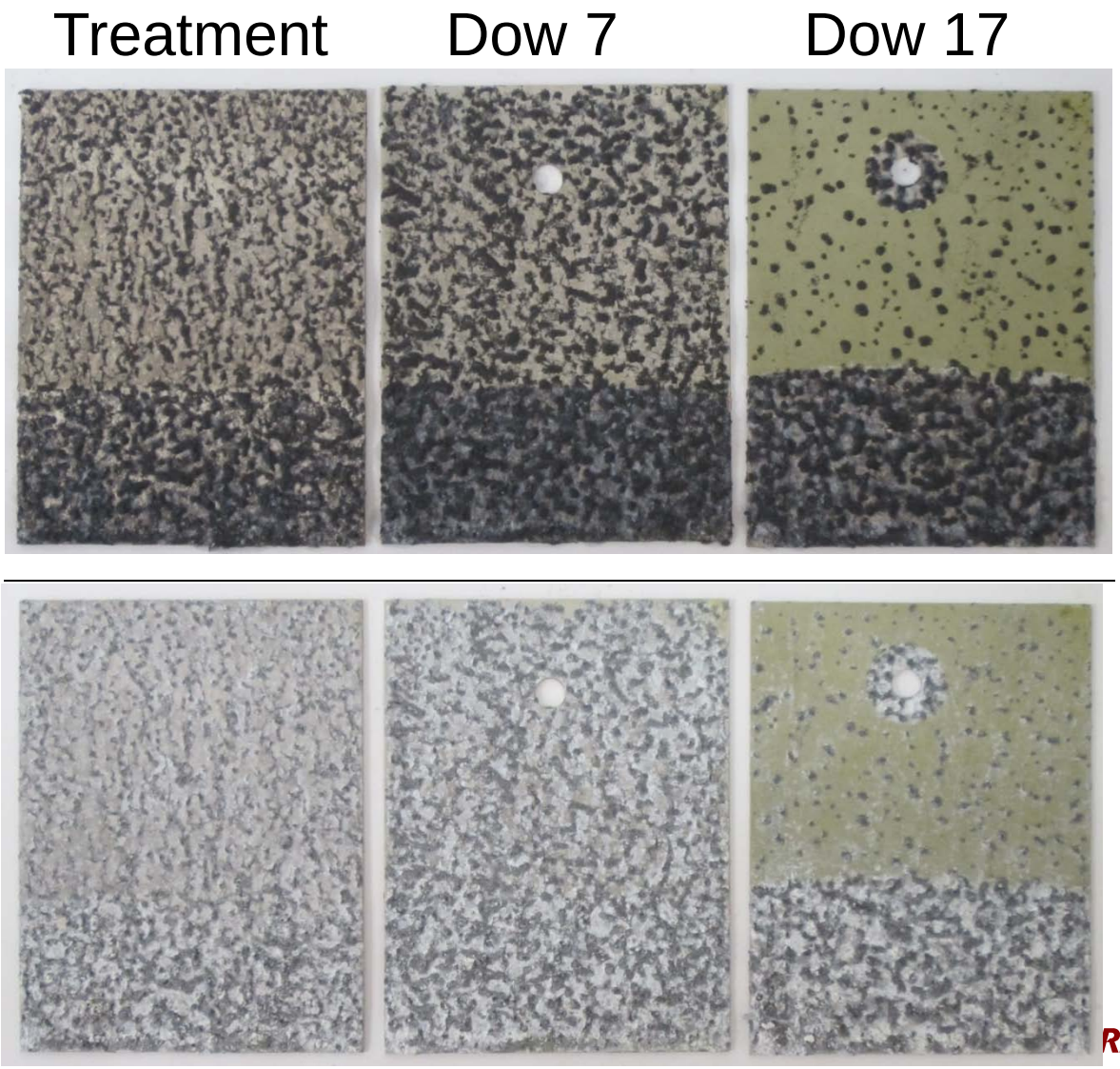
Bare and pretreated Mg AZ91D panels painted and scribed, then exposed to salt-spray test (SST). Scribe scraped after 500 hrs (upper-left limb) and after 1000 hrs (lower-left limb) exposure to salt spray.

Mg AZ31B : 0 hr SST

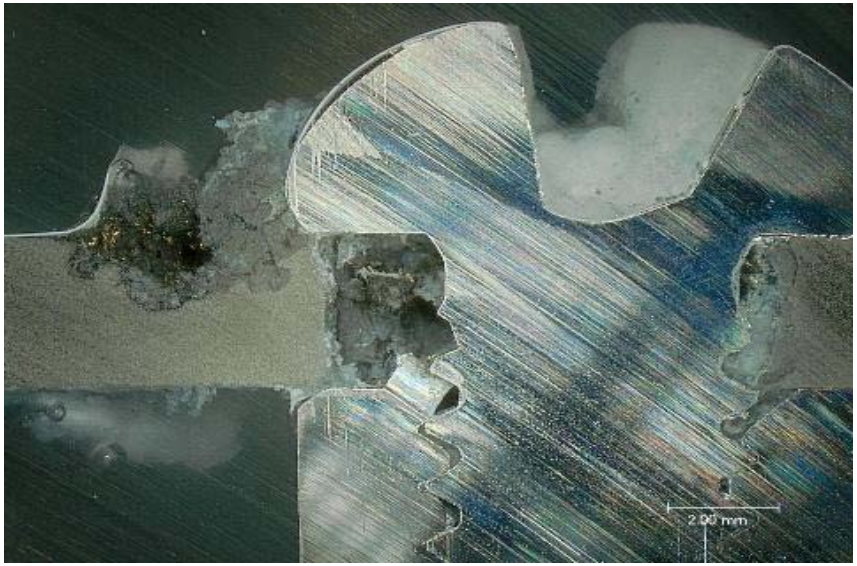
Mg AZ31B : 24 hrs SST



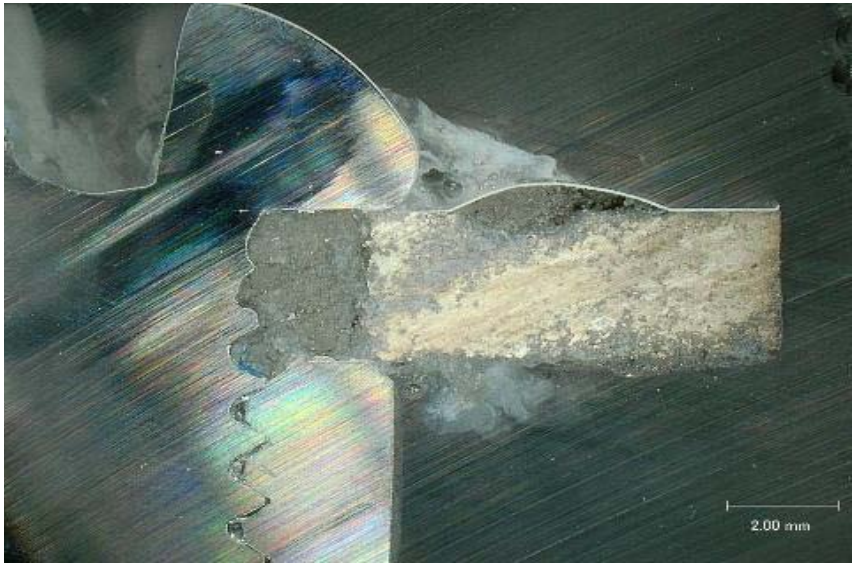
Mg AZ31B : 48 hrs SST



Zinc Plated Steel Nut and Bolt through AZ91D Panels



Dow7 with epoxy Primer



Treatment with epoxy Primer

Results/Conclusions

- Treatment (Cr^{6+} free) can be applied easily by brush or immersion application
- Treatment (performs at minimum) comparable to Dow7 on alloys tested with or without subsequent primer coating
- Treatment compatible with Dow7, Dow17 and AMS-SAE-M-3171, Type IV Replacement
- Treatment is capable of scale-up (5 gallon quantities to date)
- Treatment shows promise as a field/depot repair product for Dow7, Dow17 and AMS-SAE-M-3171, Type IV Replacement for non painted applications
- Additional work desired on other magnesium alloys with and without additional coatings and in touch-up applications.
- Additional work desired on mixed metal and various magnesium alloy applications

POTENTIAL APPLICATIONS

Develop lightweight corrosion resistant mortar fin assemblies made from magnesium

- Candidate Mg alloys: AZ61B, AZ80, AZ91D, ZK60
- Mortar fins are currently made of aluminum:

-- 2014, 2024, 6070 or, 7075 alloys

60mm Mortar:
Replace aluminum boom/fins with extruded magnesium

Mortar Base Plate:
Replace aluminum with forged magnesium

Develop corrosion resistant lightweight base plate out of magnesium

- Candidate Mg alloy: AZ80 (die cast or forged billet that will be machined to shape/size)
- Currently made of 7000 series aluminum alloy

Develop improved corrosion resistant magnesium Sabots

- Replace AZ61A with AZ61B and apply an improved coating system

Sabot:
Replace AZ61A magnesium with AZ61B

Acknowledgements:

- Thanks to Mr. Jeremy Smith and Mr. Charles Benson at Corpus Christi Army Depot (CCAD) for the preparation of Brushed Tagnite test coupons.
- Special Thanks to my associates at NEI Corp., Dr. Fred Allen, Dr. Gaurang Bhargava, Mr. Peter Hornish and Dr. Ganesh Skandan whose efforts on Contract **W15QKN-10-C-0106** made this briefing possible.


Any Questions?
EXPERIMENT IN PROGRESS
PLEASE
DO NOT TOUCH SAMPLES